MLS Scientific Publication

Scientific Themes: Microwave Remote Sensing, Cloud Ice, Dielectric Permittivity

Ice and Water Permittivities for Millimeter and Sub-millimeter Remote Sensing Applications

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Summary

Recent advances in technology result in more and more ground, air and space projects being developed to use microwave observations to analyze the Earth's atmosphere. However, there are limited measurements and modeling of dielectric properties of water and ice in the millimeter and sub-millimeter (100-3000 GHz) domain. This paper presents a literature survey of published experimental data, and provides an updated analytical model for the complex permittivity of ice for microwave remote sensing applications. The applicable frequencies of this new model range from 1 to 3000 GHz at temperatures from 0° to about –75°C. In comparison with existing laboratory data, we conclude that this model may have uncertainties of about *12%* in the imaginary part and of *5%* in the real part of ice permittivity at a frequency range of 100-1000 GHz. At higher frequencies (>1000 GHz) the uncertainties may be up to ~ *50%* in the imaginary part and ~*15%* in the real part. For liquid water, uncertainties are *5%* or less in both imaginary and real parts of the permittivity for temperature ≤ 0°C. Additional uncertainties may exist at lower temperatures where few laboratory measurements are available. Applications of this permittivity model to Microwave Limb Sounder (MLS) frequencies are demonstrated. Calculations show that such uncertainties may result in about *10-20%* likely errors in Mie extinction coefficients and single scattering albedos.

This paper provides helpful and timely contributions to the field of microwave measurement science, especially to the MLS cloud ice measurement. This work would ultimately benefit society by improving our understanding of Earth's atmosphere and climate change that could affect everyday life.

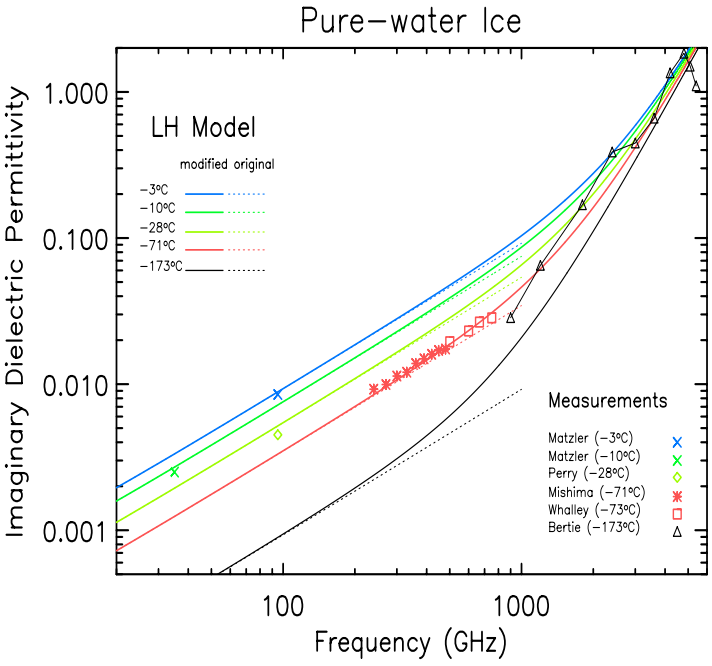

Figure 1: Model computed (lines) and laboratory measured (symbols) values of imaginary part of ice dielectric permittivity ε″. Comparison between model and measurement is discussed in the paper.

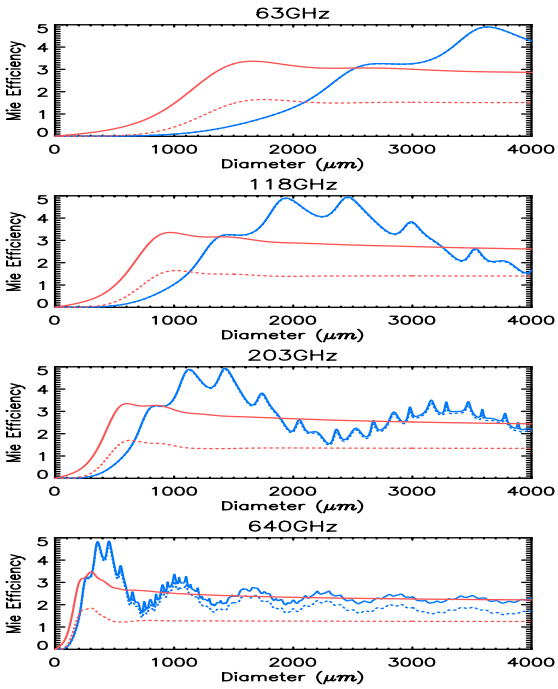

Figure 2: Mie extinction (solid line) and scattering (dotted line) efficiencies for ice (blue) and liquid water (red) with different diameters. The complex dielectric permittivities are computed at –60°C for ice and –15°C for liquid water, using the updated model.